National Aeronautics and
Space Administration
George C. Marshall Space Flight Center

CHARACTERIZATION OF RHENIUM OXIDES USING ESCA

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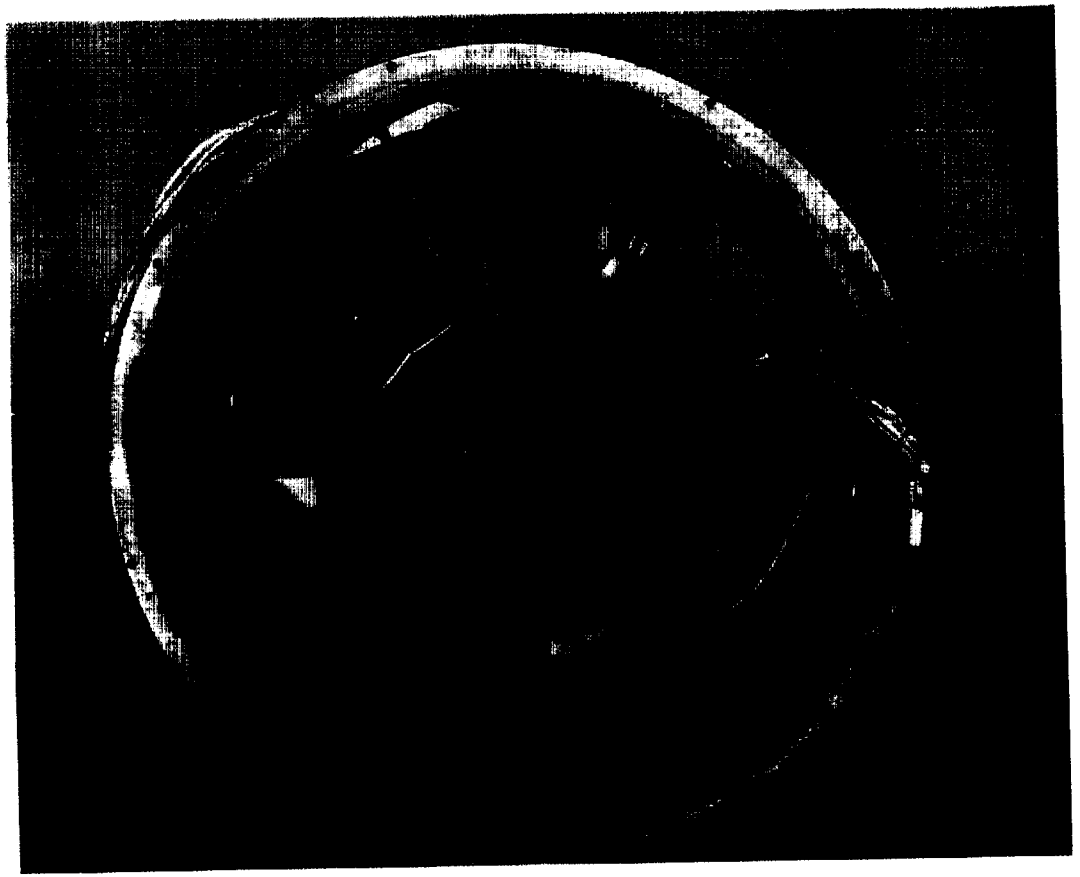
RHENIUM AS AN ENGINEERING MATERIAL

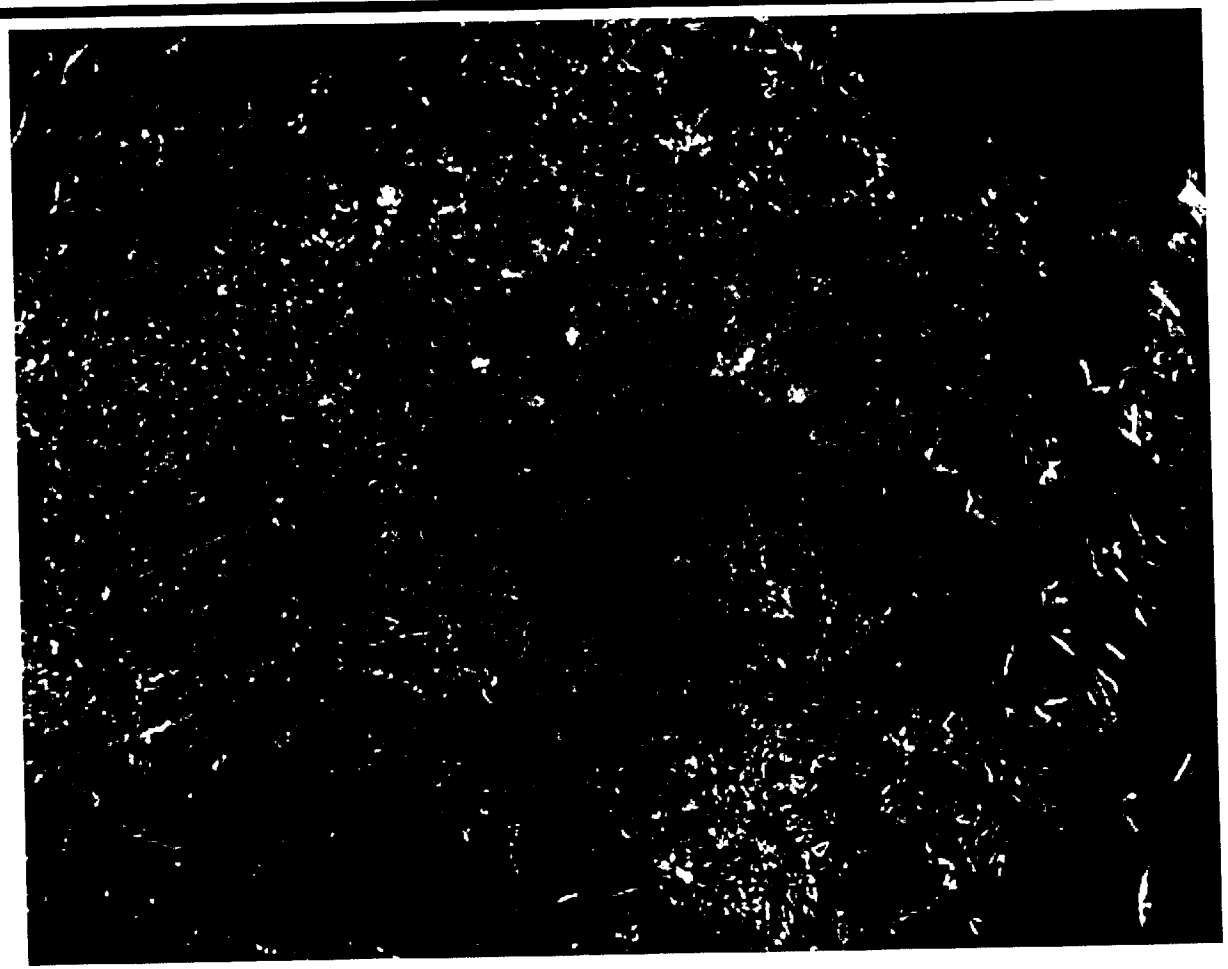
- High Melting Point – one of the Refractory metals
- High Strength at Elevated Temperature
- Excellent Toughness at at Room Temperature
- Low vapor Pressure at Melting Point
- Low Co-efficient of Thermal Expansion
- High Impact and Wear Resistance
- Compatibility with Elements such as Carbon and Platinum
- Conservation of Properties in Presence of Hydrogen, water Vapor, and Oxides of Nitrogen
- Poor Oxidation Resistance

OVERVIEW

- HISTORY
  - Rhenium as an Engineering Material
  - Testing of Rhenium Thrusters
  - Sample for Oxidation Evaluation
- EXPERIMENTAL PROCEDURE
  - Available Data
  - Data Comparison
- OXIDES OF RHENIUM
- ANALYSIS OF OXIDES
  - Spectrum from Oxides
  - Effects of Ion Sputtering
- SUMMARY OF RESULTS
- CONCLUSIONS



Test Arrangements for the Rhenium Engine



1.0 mm

Appearance of Sample Extract on Gold Sheet

AVAILABLE DATA

OXIDES	LINE POSITIONS IN ELECTRON VOLTS		
	4f7/2	4f5/2	O 1S
Pure Re	40.3	42.9	-
Re_2O_7	51.6	54.0	536.0
Re O_3	46.7	49.1	531.9
Re O_2	43.5	45.9	530.1

Ref. – (a) Handbook of X-ray Photoelectron Spectroscopy Published by Physical Electronics Inc.

(b) Broclawik, E., Harber, J., and Ungier, L. in Electronic Structure of Rhenium Oxides" J. of Physics and Chemistry of Solids, Vol. 42, 1981, pp.203 – 208.

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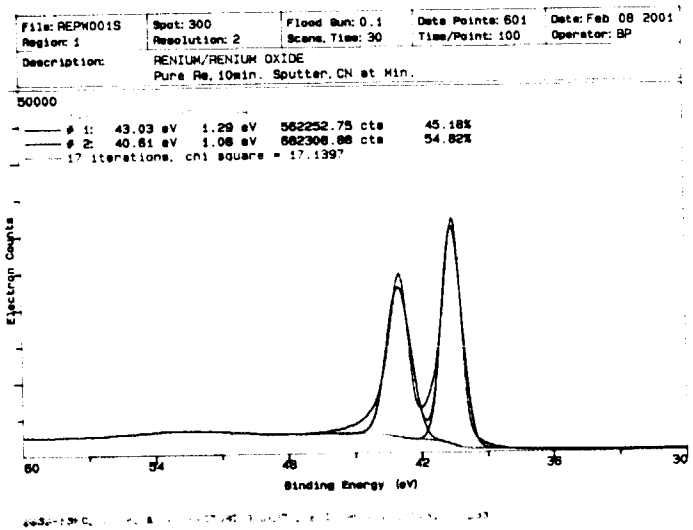

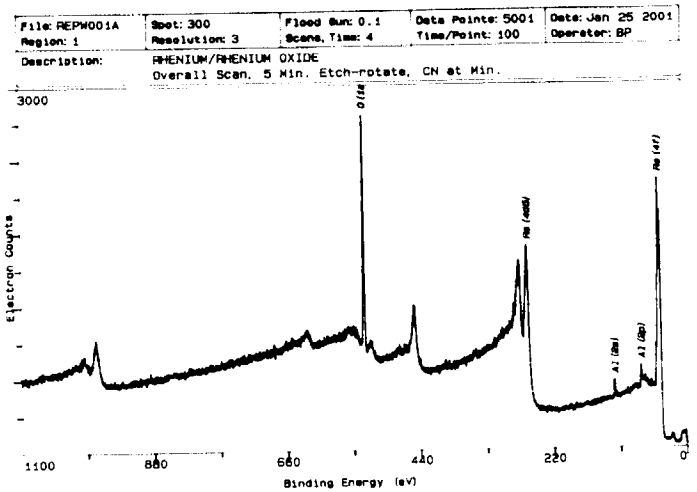

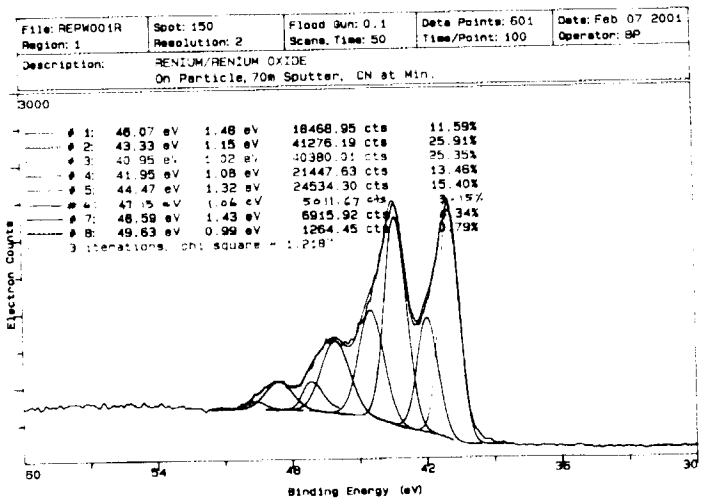

Scans From Samples

OXIDES OF RHENIUM

- **As many as seven Oxides**
- Three Oxides are well-known – Heptoxide (Re_2O_7), Trioxide ($Re\ O_3$), and Dioxide (ReO_2)
- Heptoxide absorbs moisture and converts to a transparent perrhinic acid with in seconds
- Heptoxide can be reduced to lower Oxides by CO or SO_2
- Trioxide can breakdown to lower oxides in vacuum
- Heptoxide can breakdown to lower oxides when heated in air above 120C

Ref. – (a) Druce, J. G. F. in "Rhenium", Cambridge, at The University Press, 1948, pp. 29 – 35

(b) Lebedev, K. B. in "The Chemistry of Rhenium", Translated by Ronson, L. and Woolf, A. A., Butterworth, London, 1962, pp. 13 – 17.

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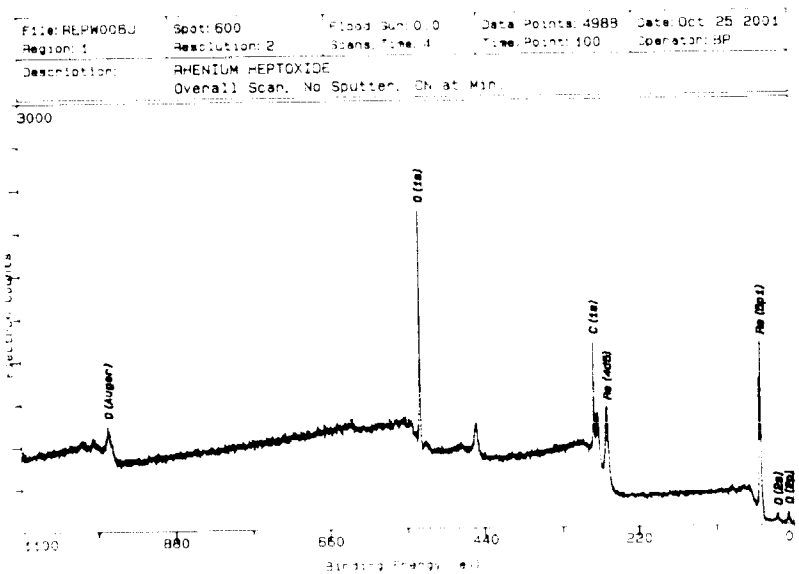

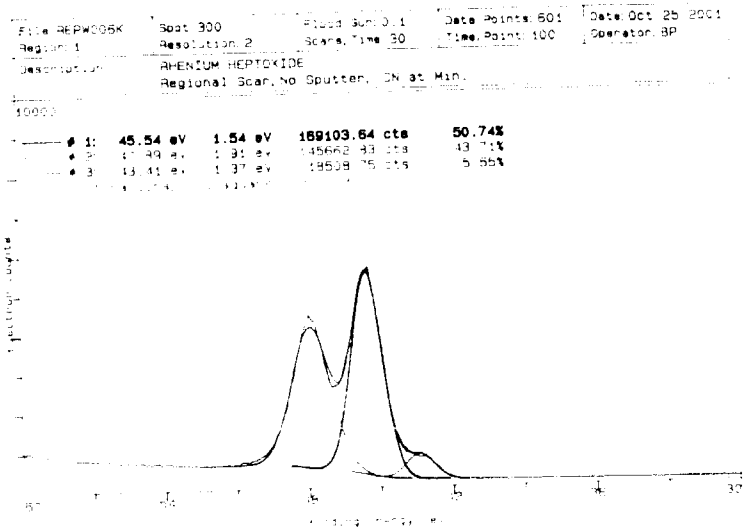

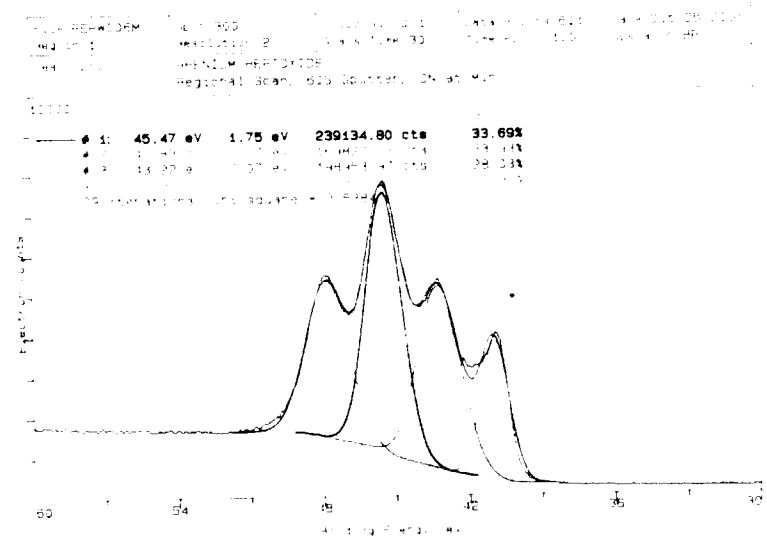

Scans From Rhenium Heptoxide

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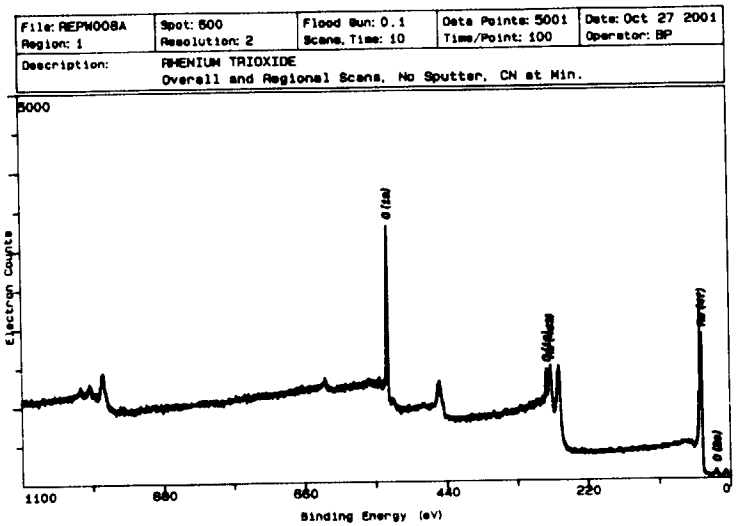
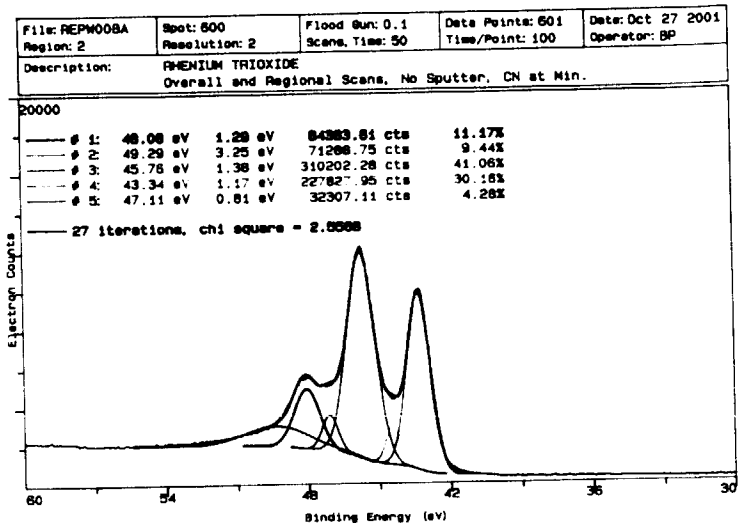
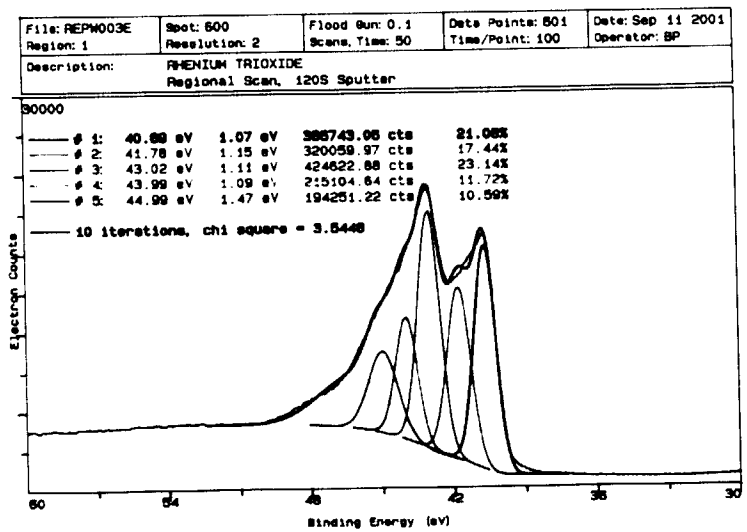
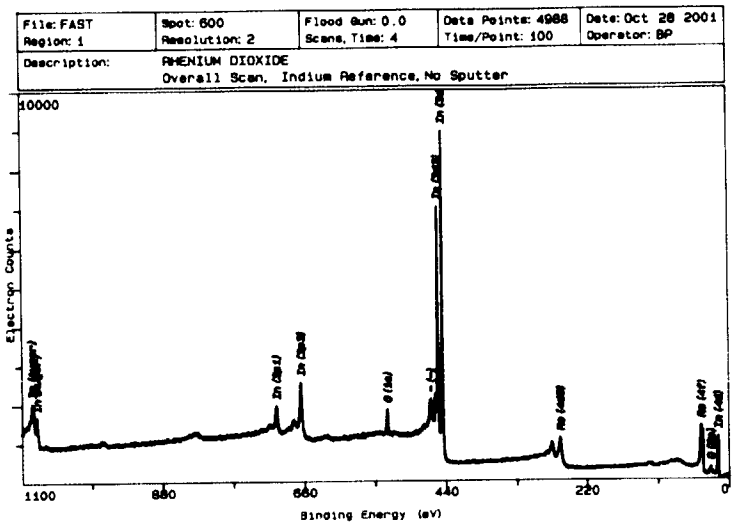
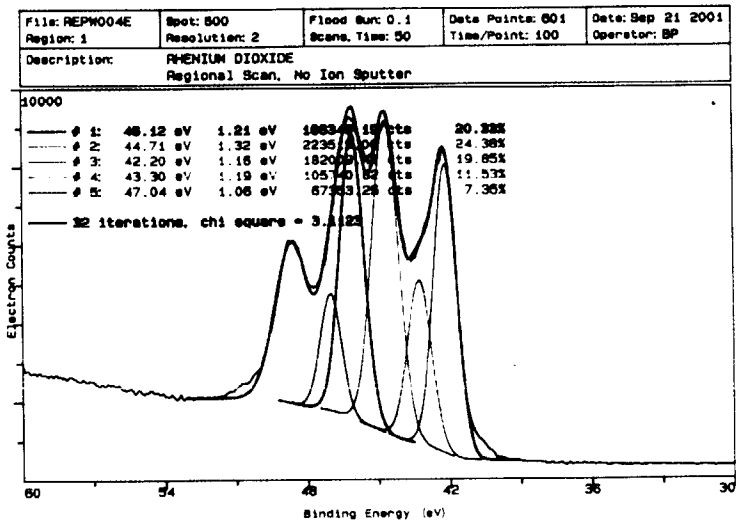




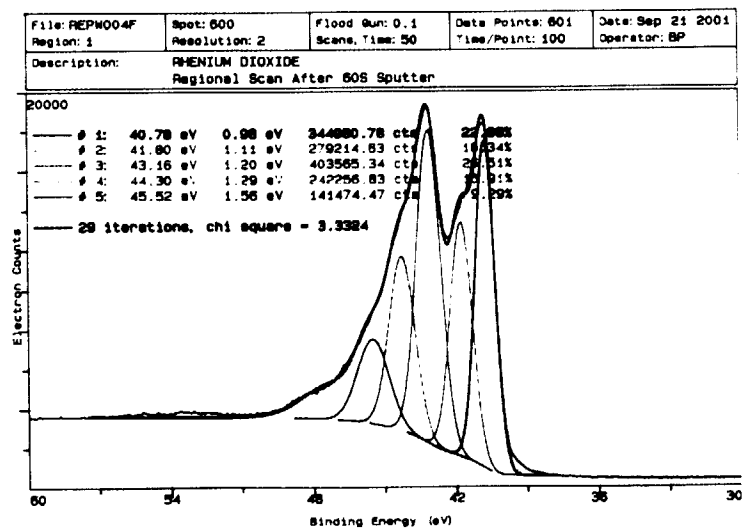
Scans From Rhenium Trioxide







Scans From Rhenium Dioxide



SUMMARY OF RESULTS

OXIDE / SAMPLE		POSITION OF RHENIUM LINES (eV)	POSITION OF OXYGEN LINE(eV)
SAMPLE	Not Sputtered		
	Sputtered	48.7, 46.2, **43.7, 41.4**	**531.2**
Re_2O_7	Not Sputtered	**48.6, 46.2, 43.7**	**531.4**
	Sputtered	48.6, **46.2**,43.8, 41.4	**531.2**
Re O_3	Not Sputtered	**49.1,** 48.1, **46.8,** 45.5, **44.3,**	**530.6,** 531.9
	Sputtered	47.0, 45.6, 44.6, **43.1, 41.3**	**530.2**
Re O_2	Not Sputtered	47.1, 44.9, **43.3, 41.0**	**530.8**
	Sputtered	46.1, 44.4, **43.2, 42.0, 40.6, 39.6**	**530.5**

CONCLUSIONS

(1) From ESCA Evaluations and the Physical Characteristics it is Clear that the Test Sample Collected from Testing is Rhenium Heptoxide

(2) Ion Beam Sputtering Changes Oxidation States of Samples to Oxides of Lower Oxidation States

(3) Pure Oxides Showed other Forms of Oxides on the Surface

Acknowledgement:

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